

U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-255 572

PLUTONIUM LEVELS IN THE SEDIMENT OF AREA
IMPOUNDMENTS ENVIRONS OF THE ROCKY FLATS
PLUTONIUM PLANT - COLORADO

ENVIRONMENTAL PROTECTION AGENCY

FEBRUARY 1975

S- 2

212029

PB 255 572

REPRODUCED BY
**NATIONAL TECHNICAL
INFORMATION SERVICE**
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

TECHNICAL REPORT DATA
(Please read instructions on the reverse before completing)

1. REPORT NO. EPA-908/2-75-001		2.	3. RECIPIENT'S ACCESSION NO.	
4. TITLE AND SUBTITLE Plutonium Levels in the Sediment of Area Impoundments Environs of the Rocky Flats Plutonium Plant - Colorado			5. REPORT DATE	
7. AUTHOR(S) Milton W. Lammering, Ph.D.			6. PERFORMING ORGANIZATION CODE	
9. PERFORMING ORGANIZATION NAME AND ADDRESS Technical Investigations Branch Surveillance & Analysis Division U.S. Environmental Protection Agency, Region VIII Denver, Colorado 80203			8. PERFORMING ORGANIZATION REPORT NO. S&A/TIB-29	
12. SPONSORING AGENCY NAME AND ADDRESS			10. PROGRAM ELEMENT NO.	
			11. CONTRACT/GRANT NO.	
			13. TYPE OF REPORT AND PERIOD COVERED Investigations 1973	
			14. SPONSORING AGENCY CODE	
15. SUPPLEMENTARY NOTES				
16. ABSTRACT Plutonium concentrations in the bed sediment of reservoirs (Great Western Reservoir, Standley Lake, Cherry Creek Reservoir, Marston Lake, and Ralston Reservoir) in the environs of the Atomic Energy Commission Rocky Flats Plant were determined by dredge and core sampling. Great Western Reservoir and Standley Lake were sampled during October, 1973; the other three impoundments during April, 1974. The baseline level of plutonium-239 in bed sediment attributable to worldwide fallout was found to be ≤ 0.10 pCi/gram (dry weight). Correspondingly, the maximum concentrations in the top layer of sediment in Great Western Reservoir were approximately 4.0 pCi/gram (dry weight). The thickness of the layer of plutonium-contaminated sediment in the reservoir was 5 cm or more at most sampling stations. Through 1973, Great Western Reservoir received liquid wastes (plutonium-bearing) from the Rocky Flats Plant via the tributary stream, Walnut Creek.				
17. KEY WORDS AND DOCUMENT ANALYSIS				
a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS		c. COSATI Field/Group
Plutonium-239, bed sediment, AEC Rocky Flats Plant.		Radiological contamination, sediment accumulation.		
		PRICES SUBJECT TO CHANGE		
18. DISTRIBUTION STATEMENT Release to the Public		19. SECURITY CLASS (This Report) unclassified		21. NO. OF PAGES 51
		20. SECURITY CLASS (This page) unclassified		22. PRICE \$4.50

TABLE OF CONTENTS

LIST OF TABLES.....	<u>Page</u> 11
LIST OF FIGURES.....	111
INTRODUCTION.....	1
SAMPLE COLLECTION AND ANALYSIS PROCEDURES.....	2
RESULTS.....	7
DISCUSSION.....	15
SUMMARY.....	17
REFERENCES.....	18
APPENDICES.....	
APPENIX A.....	A-1
APENDIX B	
Core Log.....	B-2

LIST OF TABLES

<u>No.</u>	<u>Title</u>	<u>Page</u>
I	SEDIMENT SAMPLING STATIONS/CHERRY CREEK RESERVOIR, MARSTON LAKE, AND RALSTON RESERVOIR	5
II	PLUTONIUM CONCENTRATIONS IN SEDIMENT SAMPLES/ RESERVOIRS IN THE DENVER METROPOLITAN AREA	8
III	PLUTONIUM CONCENTRATIONS IN SEDIMENT SAMPLES/ STANDLEY LAKE	9
IV	PLUTONIUM CONCENTRATIONS IN SEDIMENT SAMPLES/ GREAT WESTERN RESERVOIR	11
A-I	CESIUM-137, STRONTIUM-89 AND 90, PLUTONIUM-238 BERYLLIUM, AND POTASSIUM IN DREDGE SAMPLES/GREAT WESTERN RESERVOIR AND STANDLEY LAKE	A-2
A-II	PLUTONIUM-238 AND BERYLLIUM IN CORE SAMPLES/ GREAT WESTERN RESERVOIR AND STANDLEY LAKE	A-3
B-I	SEDIMENT SAMPLE COMPOSITION/CHERRY CREEK RESERVOIR, MARSTON LAKE, AND RALSTON RESERVOIR	B-21

LIST OF FIGURES

<u>No.</u>	<u>Title</u>	<u>Page</u>
I	BOTTOM SEDIMENT SAMPLING STATIONS/GREAT WESTERN RESERVOIR/OCTOBER 18, 1973	3
II	BOTTOM SEDIMENT SAMPLING STATIONS/STANDLEY LAKE/October 25, 1973	4
III	PLUTONIUM-239 (pCi/gram) IN DREDGE SAMPLES/GREAT WESTERN RESERVOIR/October 18, 1973	13
IV	PLUTONIUM-239 (pCi/gram) IN DREDGE SAMPLES/STANDLEY LAKE/October 25, 1973	14

INTRODUCTION

In September, 1973, the U.S. Environmental Protection Agency responded to a request from the Colorado Department of Health to assist in the investigation to verify the suspected release(s) of tritium in liquid wastes from the Rocky Flats Plant of the U.S. Atomic Energy Commission. Although focused on the determination of tritium concentrations in area surface waters and the identification of the source(s) of such contamination, the overall scope of field investigation was expanded to include the monitoring of plutonium contamination of bottom sediment in Great Western Reservoir and Standley Lake (conducted during October, 1973). Both of these reservoirs lying short distances to the east of the plant receive drainage from the site. Through 1973, Great Western Reservoir received treated liquid wastes (plutonium-bearing) from the Rocky Flats Plant via the tributary stream, Walnut Creek.

Extensive sampling of bottom sediment in Great Western Reservoir was conducted previously by the Environmental Protection Agency during September, 1970. This sampling program also involved sediment sampling of an exploratory nature in Standley Lake. As reported (1), the 1970 findings indicated the following:

- (1) Almost the entire bed of Great Western Reservoir was covered with sediment containing plutonium in excess of the estimated baseline concentration, ≤ 0.10 pCi/gram, attributable to worldwide fallout from nuclear weapons testing.
- (2) The possible existence of sectors of plutonium contamination in the deep-water area of Standley Lake attributable to "accidental" releases from the Rocky Flats Plant.

As a follow-up to these findings, the subject sediment investigation was conducted to document changes in the plutonium contamination of the sediment bed of Great Western Reservoir over the intervening period of three years - September, 1970, to October, 1973. Additionally, extensive sampling of Standley Lake sediment was conducted to confirm the presence or absence of contaminated areas.

To differentiate between sediment contamination caused by plutonium releases from the Rocky Flats Plant versus that resulting from worldwide fallout, sediment samples were collected on April 18, 1974, from Cherry Creek Reservoir, Marston Lake, and Ralston Reservoir. Considering the predominant wind direction and the distances from the plant to the reservoirs, sediment contamination in these reservoirs attributable to gaseous effluents or windborne sources (contaminated soil) originating at the Rocky Flats Plant was considered negligible. The three impoundments are not impacted by liquid effluents from the plant.

SAMPLE COLLECTION AND ANALYSIS

PROCEDURES

Bottom sediment sampling stations in Great Western Reservoir and Standley Lake are shown in Figures I and II. For these stations, the collection of dredge samples was predominant with this type collected at 37 of the 39 stations. However, the majority of the stations (21 of 39) were also characterized by the collection of both core and dredge samples. Dates of sediment collection for Great Western Reservoir and Standley Lake were October 18 and 25, respectively. Personnel from the Colorado Department of Health assisted in the collection of samples from these two impoundments.

Baseline sediment samples were collected from Cherry Creek Reservoir, Marston Lake, and Ralston Reservoir on April 18, 1974. Specific sampling locations are listed in Table I. For these impoundments, sampling was limited to dredge samples.

Dredge samples were collected by the use of a Peterson dredge (without weights). To obtain the composite dredge sample for radiological analysis, the below procedure was followed:

- (1) The sediment sample contained in the jaws of the dredge was emptied into a pan. Caution was exercised to remove the collected sample as a layer with as little disturbance as possible. The extent to which this was achieved successfully depended on the cohesiveness of the sample.
- (2) In the case of a fairly cohesive sample, the composite sample was prepared from aliquots obtained by scraping the sample surface with a hand trowel. For non-cohesive samples which underwent significant mixing in the closed dredge as well as in the process of being removed from the dredge, the composite sample was prepared from aliquots judged to be representative of the overall sample texture. That is, an attempt was made to duplicate the relative percentages of clay-like materials, silt, coarse materials (gravel, etc.) and fines (sand).

Duplicate composite samples were prepared at all locations for analysis by the Colorado Department of Health and EPA.

A Phleger Gravity Corer^(a) was used to collect all but three core samples. Shallow water depths at Stations 1, 2, and 4 in Great Western Reservoir prevented the use of the corer. These samples were collected by manually pushing the plastic core tube into the sediment bed. At all stations, field measurements of the depth of penetration of the corer and the corresponding length of the collected sample were taken to indicate the relative degree of compaction during the collection procedure. Core samples were maintained in the frozen

(a) Equipped with a 2' metal coring tube which housed a plastic core tube (1.5 inch inside diameter).

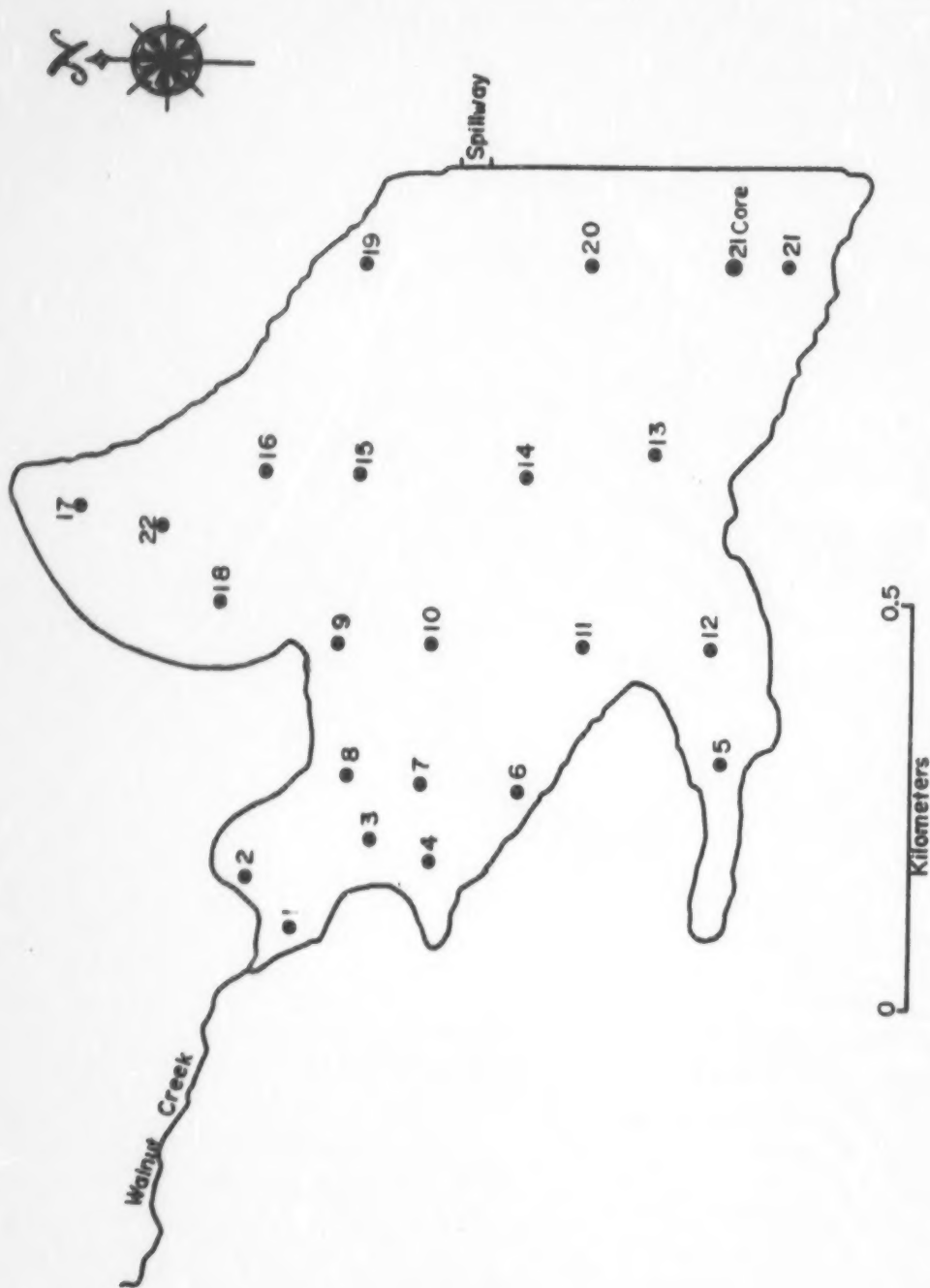


FIGURE I
BOTTOM SEDIMENT SAMPLING STATIONS
GREAT WESTERN RESERVOIR
OCTOBER 18, 1973



FIGURE II
 BOTTOM SEDIMENT SAMPLING STATIONS
 STANDLEY LAKE
 OCTOBER 25, 1973

TABLE I
SEDIMENT SAMPLING STATIONS

CHERRY CREEK RESERVOIR, MARSTON LAKE, AND RALSTON RESERVOIR

<u>Reservoir</u>	<u>Station Number</u>	<u>Location</u>
Cherry Creek Reservoir (approximately 24 miles southeast of the Rocky Flats Plant)	CC-1	Approx. 180 meters from the inlet
	CC-2	Approx. 90 meters from the dam
Marston Lake (approximately 19 miles southeast of the Rocky Flats Plant)	M-1	Approx. 45 meters from the inlet
	M-2	Approx. 45 meters from the inlet
Ralston Reservoir (approximately 3 miles south of the Rocky Flats Plant)	R-1	Approx. 45 meters from the head end (mouth of Ralston Creek)
	R-2	Approx. 0.4 kilometers from the head end
	R-3	Approx. 0.8 kilometers from the head end (equidistant between the head end and the dam)
	R-4	Approx. 0.4 kilometers from the dam
	R-5	Approx. 45 meters from the dam

state during the interim period between collection and processing.^(a) A selected number of core sections were provided to Dow Chemical Company for their own analyses.

All EPA samples were analyzed in the Office of Radiation Programs radiochemistry laboratory, National Environmental Research Center, Las Vegas, Nevada. Dredge samples were analyzed for plutonium-238 and 239, cesium-137, beryllium, and potassium; selected samples also were analyzed for strontium-89 and 90. Core sections were analyzed for plutonium-239 with selected sections also analyzed for plutonium-238 and beryllium.

-
- (a) The process of "sectioning" each core sample initially involved thawing the sample and subsequently forcing the water out of the tube by pushing the sediment core upward with a metal plunger (core tube in a vertical position). The core sample was then sectioned by a stepwise process of pushing the sediment core upward and out of the tube, the exposed increment or step in each case being equal to the desired length of the core section. During the sectioning process, the core tube was held in a vertical position and the desired core section was pushed into an inverted glass jar held at the end of the tube. A wide-blade knife was used to cut each section.

RESULTS

Plutonium-239 results for core and dredge samples from the five impoundments - Cherry Creek Reservoir, Marston Lake, Ralston Reservoir, Standley Lake, and Great Western Reservoir - are presented in Tables II - IV. The plutonium-239 results for dredge samples from Great Western Reservoir and Standley Lake also are shown in Figures III and IV. Analytical data for other parameters (cesium-137, strontium-89 and 90, plutonium-238, beryllium and potassium) are presented in Appendix A.

Physical descriptions of the core samples, including compaction measurements, and corresponding photographs of the samples prior to "sectioning" are compiled in Appendix B. The compositions of dredge samples from Cherry Creek Reservoir, Marston Lake, and Ralston Reservoir are described in this same appendix.

TABLE II
PLUTONIUM CONCENTRATIONS IN SEDIMENT SAMPLES
RESERVOIRS IN THE DENVER METROPOLITAN AREA

<u>Reservoir and Station</u>	<u>Approximate Water Depth (meters)</u>	<u>Plutonium-239 (pCi/gram)(a)</u>
Cherry Creek Reservoir		
CC-1	4.5	<0.01
CC-2	6.0	<0.05
Marston Lake		
M-1	3.6	<0.02
M-2	4.5	0.13(b)
Ralston Reservoir		
R-1	2.4	<0.06
R-2	1.5	0.03
R-3	24	<0.03
R-4	33	0.04
R-5	33	0.06

(a) Dry weight basis

(b) Result verified by replicate analysis

TABLE III

PLUTONIUM CONCENTRATIONS IN SEDIMENT SAMPLESSTANDLEY LAKE

Station	Approximate Water Depth (meters)	Dredge Sample Plutonium-239 (pCi/gram)(a)	Core Sample	
			Core(b) Section (cm)	Plutonium-239 (pCi/gram)(a)
1	0.6	0.11	No Core	
2	0.8	0.04	No Core	
3	3.5	0.05	No Core	
4	1.0	0.04	0 - 2.54 7.62 - 10.2	<0.06 <0.04
5	4.5	0.08	0 - 2.54 10.2 - 12.7	0.08 <0.03
6	5.0	0.08	No Core	
7	9.5	0.15	0 - 2.54 2.54 - 5.08 14.0 - 16.5	<0.06 <0.07 <0.08
8	4.0	0.08	0 - 2.54 8.89 - 11.4	<0.09 <0.07
9	2.5	<0.02	No Core	
10	1.0	0.08	No Core	
11	4.5	0.03	No Core	
12	13	0.10	0 - 2.54 2.54 - 5.08 17.8 - 20.3	0.10 <0.08 <0.03
13	6.0	0.03	0 - 2.54 7.62 - 10.2	<0.06 <0.06

(a) Dry weight basis.

(b) The limits of the range are measurements in centimeters from the top surface of the core sample. No correction was made for compaction during sample collection.

TABLE III (continued)

Station	Approximate Water Depth (meters)	Dredge Sample Plutonium-239 (pCi/gram) ^(a)	Core Sample	
			Core ^(b) Section (cm)	Plutonium-239 (pCi/gram) ^(a)
14	6.0	0.08	No Core	
15	6.0	<0.06	No Core	
16	21	0.17	0 - 2.54	<0.10
			10.2 - 12.7	0.11
			15.2 - 17.8	0.07
			27.9 - 30.5	<0.04
17	9.0	<0.03	0 - 2.54	<0.16
			5.08 - 8.89	<0.04

TABLE IV

PLUTONIUM CONCENTRATIONS IN SEDIMENT SAMPLESGREAT WESTERN RESERVOIR

Station	Approximate Water Depth (meters)	Dredge Sample Plutonium-239 (pCi/gram)(a)	Core Sample	
			Core(b) Section (cm)	Plutonium-239 (pCi/gram)(a)
1	0.5	2.0	0 - 2.54 2.54 - 5.08 14.0 - 16.5	1.0 1.3 0.10
2	0.6	0.61	0 - 2.54 2.54 - 5.08 6.35 - 8.89	0.54 0.25 <0.02
3	2.5	2.9	No Core	
4	0.5	0.46	0 - 3.49 4.45 - 8.89	0.25 <0.02
5	1.0	0.18	0 - 2.54 2.54 - 5.08 7.62 - 10.2	0.57 0.61 <0.07
6	4.0	No Dredge Sample	0 - 2.54 2.54 - 5.08 10.2 - 12.7	0.47 <0.07 <0.07
7	4.0	2.5	0 - 2.54 2.54 - 5.08 12.7 - 15.2	3.8 <0.06 <0.03
8	3.5	1.4	0 - 2.54 2.54 - 5.08 17.8 - 20.3	2.6 4.5 <0.03
9	0.6	0.10	No Core	
10	5.5	2.3	No Core	
11	3.5	1.2	No Core	
12	5.5	<0.06	No Core	

(a) Dry weight basis

(b) The limits of the range are measurements in centimeters from the top surface of the core sample. No correction was made for compaction during sample collection.

TABLE IV (continued)

Station	Approximate Water Depth (meters)	Dredge Sample Plutonium-239 (pCi/gram)(a)	Core Sample	
			Core(b) Section (cm)	Plutonium-239 (pCi/gram)(a)
13	3.5	0.44	0 - 2.54 8.89 - 11.4	0.34 <0.06
14	9.5	4.1	0 - 2.54 2.54 - 5.08 17.8 - 20.3	2.6 2.2 <0.08
15	9.3	2.5	0 - 2.54 5.08 - 7.03	0.30 <0.07
16	4.5	0.62	0 - 3.81 3.81 - 6.35 11.4 - 14.0	1.3 0.35 <0.08
17	2.3	0.68	No Core	
18	0.8	0.19	No Core	
19	9.0	1.8	0 - 2.54 2.54 - 5.08 12.7 - 15.2	3.9 1.9 <0.04
20	12	3.8	0 - 1.91 1.91 - 3.18 13.7 - 16.2	3.8 4.4 <0.04
21 ^(c)	7.3	0.29	0 - 2.54 2.54 - 5.08 17.1 - 19.7	2.2 0.71 <0.04
22	No Measurement	No Dredge Sample	0 - 2.54 5.08 - 7.62 12.7 - 15.2	0.10 <0.10 <0.04

(c) As shown in Figure I, the core and dredge samples for this sampling station designation were not collected in the same approximate location. The dredge sample was collected more inshore in shallow water.

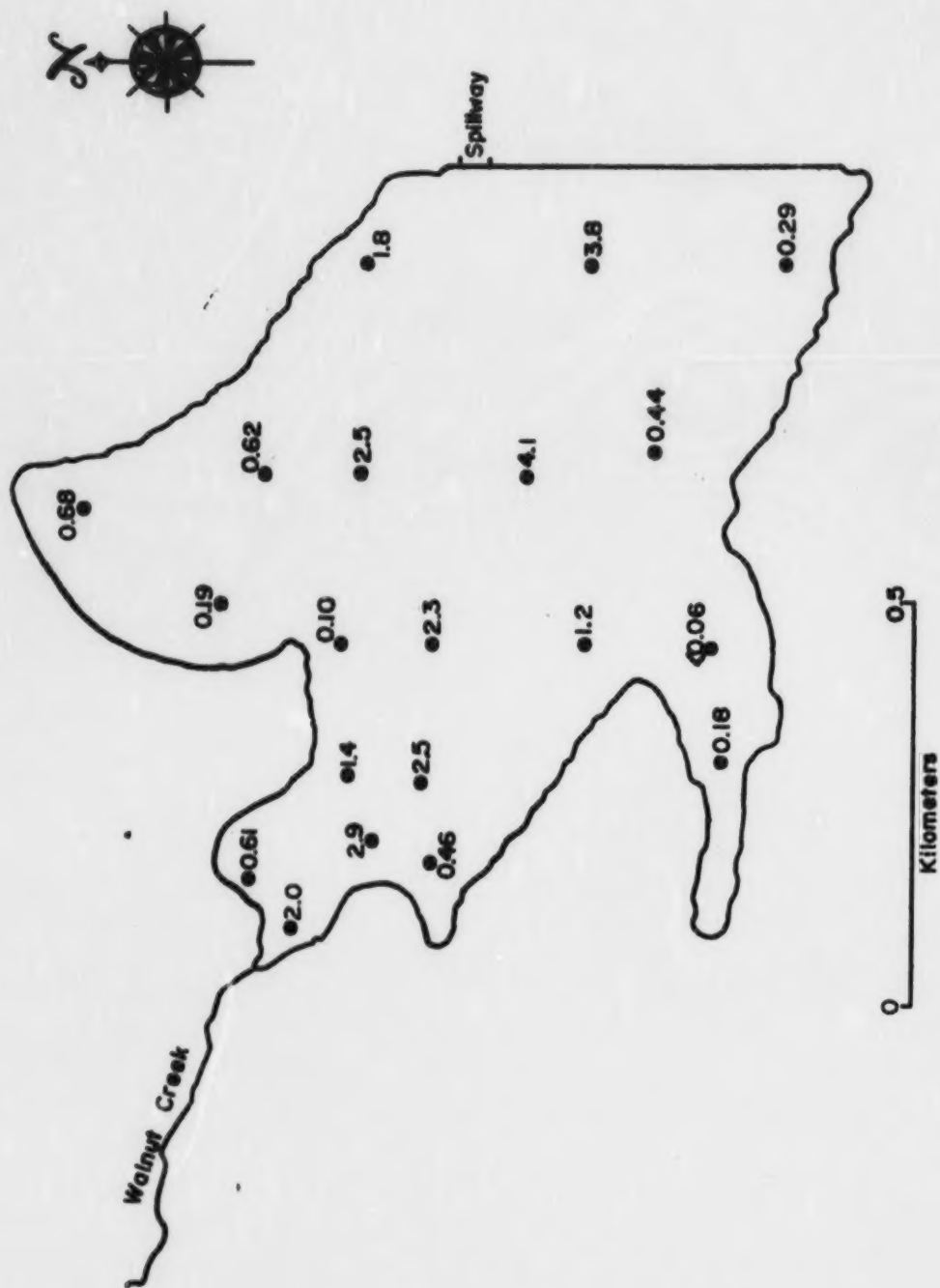


FIGURE III
PLUTONIUM-239 (pCi/gram) IN DREDGE SAMPLES
GREAT WESTERN RESERVOIR
OCTOBER 18, 1973

DISCUSSION

With one exception (Station M-2, Marston Lake), dredge samples from Cherry Creek Reservoir, Marston Lake, and Ralston Reservoir contained plutonium-239 at concentrations substantially below 0.10 pCi/gram (Table II). This confirmed previous findings leading to the conclusion that the baseline level of plutonium-239 contamination in the bed sediment of area surface waters is typically less than 0.10 pCi/gram. The sediment concentration of 0.13 pCi/gram obtained for Station M-2 on Marston Lake was considered to be more of a spurious result than a real concentration. The factors which could have contributed to a "high" result were many. However, since the composite sample was analyzed in duplicate, the reason was more probably one of sample collection and preparation as opposed to analytical inaccuracies. That is, the composite sample prepared from the Petersen dredge sample may have been biased in the percentage of "fines" and somewhat unrepresentative of actual bed conditions.

Taken collectively, the plutonium-239 results for sediment samples collected from Standley Lake did not indicate any discernible contamination attributable to the Rocky Flats Plant (Table III). Only the dredge samples from Stations 7 and 16 showed concentrations slightly in excess of the established baseline value (0.15 and 0.17 pCi/gram versus <0.10 pCi/gram). However, core samples from these two locations were characterized by baseline levels in all analyzed sections. Accordingly, baseline conditions were concluded to be existent at these two locations since the core samples were more representative of the undisturbed sediment bed.^(a) Analysis of core sections from all other sampling locations also showed baseline concentrations of plutonium-239. Compared to the findings of the 1970 study, the indication of possible contamination to a depth of approximately 30 cm (compacted) in the deep water area near the dam was not verified.

Plutonium-239 results for dredge samples and the top sections (≤ 2.54 cm) of the core samples showed contamination attributable to liquid wastes from the Rocky Flats Plant over almost the entire bed of Great Western Reservoir (Table IV). Consistent with the 1970 study, the zone or area of highest contamination was the central section of the reservoir (inlet to dam). Areas of minimum impact^(b) were the south arm (Stations 5 and 12), the shallow-water, shoreline area between the south arm and the dam (Station 21-dredge), and the western portion of the north arm (Stations 9, 18, and 22). The major differences between the 1970 and 1973 studies were the following:

- (1) Over the three year period between sediment sampling efforts, the plutonium-239 concentrations in the upper sediment layer increased significantly.
-
- (a) In comparison to a dredge sample, the core sample represents a relatively undisturbed segment of the sediment bed. There is little mixing of sediment particles in a vertical direction although significant compaction of unconsolidated material does occur.
 - (b) Plutonium-239 concentrations less than 0.30 pCi/gram.

ificantly. Whereas the maximum concentration observed in 1970 was 0.86 pCi/gram, the October, 1973, study showed eleven (11) stations characterized by plutonium-239 concentrations greater than 1.0 pCi/gram. The maximum concentration was 4.1 pCi/gram (Station 14).

- (2) In contrast to the 1970 observation of maximum concentrations occurring in the reservoir inlet area (adjacent to the mouth of Walnut Creek) the 1973 study showed maximum concentrations in the deep-water area of the reservoir (Stations 14 and 20).

The core samples supported the previous finding of plutonium contamination extending to depths of 5 cm or more (compacted) at most locations (Table IV). Generalized, the typical concentration-sediment depth (thickness) profile was one of decreasing concentrations with increased sediment thickness.

Comparing the Great Western Reservoir plutonium-239 results for dredge samples with those for corresponding top sections of core samples showed no better than "order-of-magnitude" agreement at each station. The reasons for the lack of relatively close agreement in terms of absolute concentration values are considered to be physical differences introduced by sampling techniques and procedures. As noted in a previous footnote, the dredge and core collection procedures produce disturbed and undisturbed samples, respectively. The other factor of importance was the field procedure involving the collection of core samples as a separate activity following the completion of dredge sample collection. This involved revisiting each sampling site a second time. Since the location of each sampling station was determined by "eye" from references to unique shoreline features, the sampling stations shown in Figure I represent general areas of limited size and not specific points. Hence, the dredge and core samples for any given sampling location represented samples collected from only the same general area and were expected to show variations in concentrations.

The cesium-137, strontium-89/90, plutonium-238, and beryllium data for core and dredge samples from Great Western Reservoir and Standley Lake did not indicate significant differences within a given impoundment or between the two impoundments (Appendix A).

SUMMARY

The October, 1973, sediment study of Standley Lake and Great Western Reservoir and the April, 1974, sediment study of Cherry Creek Reservoir, Marston Lake, and Ralston Reservoir produced the following significant findings.

- (1) In the environs of the Rocky Flats Plant, the baseline level of plutonium-239 in the bed sediment of impoundments is ≤ 0.10 pCi/gram (dry weight).
- (2) Sediment throughout Standley Lake was found to contain plutonium-239 at baseline levels.
- (3) Plutonium contaminated sediment attributable to the routine discharge of plutonium-bearing liquid wastes from the Rocky Flats Plant occurred throughout Great Western Reservoir. Maximum concentrations in the top layer of sediment (2.54 cm.- compacted) were approximately 40X the baseline concentration; i.e. approximately 4.0 pCi/gram (dry weight). The thickness of the layer of plutonium-contaminated sediment was 5 cm or more at most sampling stations.

REFERENCES

- (1) U.S. Environmental Protection Agency, "Radioactivity Levels In The Environs Of The Rocky Flats Plutonium Plant, Colorado, 1970 - Part II" Technical Investigations Branch, Surveillance and Analysis Division, Region VIII, SA/TIB-26 (December 15, 1973).

APPENDIX A

TABLE A-1

CESIUM-137, STRONTIUM-89 AND 90, PLUTONIUM-238, BERYLLIUM, AND POTASSIUM IN DREDGE SAMPLESGREAT WESTERN RESERVOIR AND STANDLEY LAKE

Station	Concentration (Dry Weight Basis)					
	Cesium-137 (pCi/g)	Strontium-89 (pCi/g)	Strontium-90 (pCi/g)	Plutonium-238 (pCi/g)	Beryllium (μ g/g)	Potassium (μ g/g)
<u>Great Western Reservoir</u>						
1	1.0	<1.9	<0.82	<0.05	<2.0	29
2	0.97	<1.9	<0.82	<0.04	<2.0	27
3	1.1	<1.9	<0.82	0.05	0.6	29
4	0.52	<1.9	<0.82	<0.06	0.6	28
5	0.21	<1.9	<0.82	0.03	1.2	24
7	1.0	<1.9	<0.82	0.11	1.0	30
8	1.0	<1.9	<0.82	<0.06	1.0	22
9	0.17	-	-	<0.05	0.5	21
10	1.1	-	-	0.11	1.3	26
11	0.87	-	-	<0.04	1.2	27
12	1.3	-	-	<0.05	1.3	26
13	1.6	-	-	0.33	1.3	30
14	2.1	-	-	0.29	1.4	30
15	2.3	-	-	0.10	1.5	28
16	1.2	-	-	0.07	1.0	29
17	1.2	-	-	<0.06	0.7	28
18	0.94	-	-	0.06	0.9	29
19	1.4	-	-	<0.07	1.0	30
20	2.0	-	-	0.14	1.4	34
21	0.25	-	-	0.09	0.5	21
<u>Standley Lake</u>						
1	2.3	-	-	<0.07	1.0	28
2	1.1	-	-	<0.06	0.9	23
3	1.0	-	-	<0.04	0.7	19
4	0.20	<2.0	<1.0	0.07	0.7	19
5	2.0	-	-	<0.11	0.9	29
6	2.3	-	-	<0.09	1.2	32
7	2.3	-	-	0.06	1.0	32
8	0.73	<2.1	<1.1	<0.03	0.9	26
9	0.26	<2.6	<1.3	<0.04	1.0	28
10	1.0	<2.2	<1.1	<0.05	0.9	20
11	0.58	-	-	<0.05	0.7	27
12	1.7	-	-	<0.04	1.4	30
13	0.68	<2.5	<1.2	<0.05	0.8	12
14	1.9	-	-	<0.03	1.3	26
15	0.91	-	-	<0.05	1.2	23
16	2.4	<2.3	<1.2	<0.06	2.0	35
17	0.70	-	-	<0.05	1.4	23

TABLE A-II

PLUTONIUM-238 AND BERYLLIUM IN CORE SAMPLESGREAT WESTERN RESERVOIR AND STANDLEY LAKE

Station	Core (a) Section (cm)	Concentration (Dry Weight Basis)	
		Plutonium-238 (pCi/g)	Beryllium (µg/g)
Great Western Reservoir			
1	0 - 2.54	<0.04	<0.5
	2.54 - 5.08	<0.05	<0.5
	14.0 - 16.5	<0.06	0.6
2	0 - 2.54	0.04	0.6
	2.54 - 5.08	<0.06	0.7
	6.35 - 8.89	<0.04	0.8
4	0 - 3.49	<0.05	0.9
	4.45 - 8.89	<0.05	1.1
5	0 - 2.54	<0.05	1.2
	2.54 - 5.08	<0.04	0.9
	7.62 - 10.2	<0.05	1.0
6	0 - 2.54	<0.05	1.2
	2.54 - 5.08	<0.06	1.4
	10.2 - 12.7	<0.06	1.1
7	0 - 2.54	<0.05	1.0
	2.54 - 5.08	<0.05	0.9
	12.7 - 15.2	<0.05	1.0
8	0 - 2.54	<0.06	1.0
	2.54 - 5.08	<0.05	1.5
	17.8 - 20.3	<0.05	1.0
13	0 - 2.54	<0.05	0.8
	8.89 - 11.4	<0.06	0.7
14	0 - 2.54	<0.05	1.0
	2.54 - 5.08	<0.06	1.8
	17.8 - 20.3	<0.07	1.0

(a) The limits of this range are measurements in centimeters from the top surface of the core sample. No correction was made for compaction during sample collection.

TABLE A-II (continued)

Station	Core(a) Section (cm)	Concentration (Dry Weight Basis)	
		Plutonium-238 (pCi/g)	Beryllium (μ g/g)
Great Western Reservoir			
15	0 - 2.54	<0.05	0.5
	5.08 - 7.03	<0.06	1.0
16	0 - 3.81	<0.05	0.9
	3.81 - 6.35	<0.05	0.9
	11.4 - 14.0	<0.07	1.0
19	0 - 2.54	0.05	1.7
	2.54 - 5.08	<0.05	1.3
	13.7 - 16.2	<0.05	1.4
20	0 - 1.91	0.08	1.9
	1.91 - 3.18	<0.06	1.3
	13.7 - 16.2	<0.05	1.3
21	0 - 2.54	<0.05	1.2
	2.54 - 5.08	<0.05	0.7
	17.1 - 19.7	<0.05	1.2
22	0 - 2.54	<0.05	0.8
	5.08 - 7.62	<0.07	0.9
	12.7 - 15.2	<0.05	1.0
Standley Lake			
4	0 - 2.54	<0.05	<2.0
	7.62 - 10.2	<0.04	<2.0
5	0 - 2.54	<0.05	<2.0
	10.2 - 12.7	<0.05	<2.0
7	0 - 2.54	<0.04	<2.0
	2.54 - 5.08	<0.06	<2.0
	14.0 - 16.5	<0.05	<2.0
8	0 - 2.54	<0.08	<2.0
	8.89 - 11.4	<0.05	<2.0
12	0 - 2.54	<0.04	<2.0
	2.54 - 5.08	<0.05	<2.0
	17.8 - 20.3	<0.05	<2.0

TABLE A-II (continued)

Station	Core(a) Section (cm)	Concentration (Dry Weight Basis)	
		Plutonium-238 (pCi/g)	Beryllium (μ g/g)
Standley Lake 13	0 - 2.54	<0.04	<2.0
	7.62 - 10.2	<0.05	<2.0
16	0 - 2.54	<0.05	<2.0
	10.2 - 12.7	<0.07	<2.0
	15.2 - 17.8	<0.05	<2.0
	27.9 - 30.5	<0.05	<2.0
17	0 - 2.54	<0.11	<2.0
	5.08 - 8.89	<0.05	<2.0

APPENDIX B

CORE LOG

Great Western Reservoir

Station 1

Collection - Core collected by manually pushing the plastic
core tube into the sediment bed

Total penetration - 16.5 cm

Total core length - 16.5 cm

Description

0 - 5.08 cm	Silt and sand mixture; predominately brown sand.
5.08 - 10.2 cm	Gradation from sandy composition to clay.
10.2 - 16.5 cm	Brown clay.

Station 2

Collection - Core collected by manually pushing the plastic core tube into the sediment bed.

Total penetration - 8.89 cm

Total core length - 8.89 cm

Description

0 - 2.54 cm	Loose, brown material; "flocculent-like." Some black matter.
2.54 - 5.08 cm	Same as top 2.54cm except for slight increase in the amount of black matter.
5.08 - 8.89 cm	Clay embedded with vegetation fragments (roots, etc.)

Station 4

Collection - Core collected by manually pushing the plastic core tube into the sediment bed.

Total penetration - 8.89 cm

Total core length - 8.89 cm

Description

0 - 3.49 cm	Loose, brown sediment; "flocculent-like."
3.49 - 4.76 cm	No description.
4.76 - 8.89 cm	Predominately brown clay; some gray streaks.

Station 5

Collection - Phleger Gravity Corer

Total penetration - 12.7 cm

Total core length - 12.7 cm

Description

0 - 5.08cm

Unconsolidated silt; brown color.

5.08 - 12.7 cm

Some decaying organic matter; black color.

Clay with some sand and plant detritus.

Station 6

Collection - Phleger Gravity Corer

Total penetration - 28.7 cm

Total core length - 15.2 cm

Description

0 - 2.54 cm	Silt and sand; predominately sand, brownish-black.
2.54 - 5.08 cm	Extremely thin overlay of sandy material on grayish-brown clay.
5.08 - 7.62	No description.
7.62 - 15.2 cm	Grayish-brown clay.

Station 7

Collection - Phleger Gravity Corer

Total penetration - 26.0 cm

Total core length - 17.1 cm

Description

0 - 2.54 cm	Unconsolidated silt; brownish-black.
2.54 - 5.08 cm	Transition zone from silt to clay. The unconsolidated silt extended in an irregular pattern to depths of 3.81 to 4.45cm.
5.08 - 12.7 cm	No description.
12.7 - 17.1 cm	Brown clay with gray flecks.

Station 8

Collection - Phleger Gravity Corer

Total penetration - 40.6 cm

Total core length - 25.4 cm

Description

0 - 5.08 cm	Dark brown silt.
5.08 - 8.89 cm	Gradation from dark brown silt to light gray clay. Gravel in the clay at a depth of 7.62 cm.
8.89 - 14.0 cm	Gradation from light gray clay to light brown clay.
14.0 - 25.4 cm	Light brown clay interspersed with chunks of sand and gravel.

Station 13

Collection - Phleger Gravity Corer

Total penetration - 22.2 cm

Total core length - 14.6 cm

Description

0 - 2.54 cm	Mixture of dark brown silt, sand, and gravel.
2.54 cm - 5.08 cm	Gradation to gray clay.
5.08 - 14.6 cm	Gray clay.

Station 14

Collection - Phleger Gravity Corer

Total penetration - 48.3 cm

Total core length - 23.5 cm

Description

0 - 5.08 cm	Black matter; organic.
5.08 - 12.7 cm	Gradation from black matter to clay (mixture of brown and gray).
12.7 - 23.5 cm	Grayish-brown clay.

Station 15

Collection - Phleger Gravity Corer

Total penetration - 10.8 cm

Total core length - 9.53 cm

Description

0 - 1.91 cm
1.91 - 3.81 cm
3.81 - 9.53 cm

Unconsolidated, dark brown silt.
Gradation to light brown clay.
Light brown clay.

Station 16

Collection - Phleger Gravity Corer

Total penetration - 25.4 cm

Total core length - 16.5 cm

Description

Sandy clay; dark brown color; pebbles throughout the core.

Station 19

Collection - Phleger Gravity Corer

Total penetration - 73.7 cm

Total core length - 22.2 cm

Description

0	-	1.91 cm	Dark brown sediment; "flocculent-like."
1.91	-	9.53 cm	Mixture of black and dark brown sediment.
9.53	-	12.1 cm	Gradation to grayish-brown clay.
12.1	-	14.6 cm	Gradation to gray clay.
14.6	-	15.2 cm	Gradation to brown clay.
15.2	-	16.5 cm	Brown clay.

Station 20

Collection - Phleger Gravity Corer

Total penetration - 114.3 cm

Total core length - 27.9 cm

Description

0 - 1.91 cm	Dark brown sediment; "light-weight" material.
1.91 - 3.18 cm	Band of light brown clay.
3.18 - 10.2 cm	Grayish-black matter; some areas of dark brown color.
10.2 - 27.9 cm	Dark gray matter; "ooze."

Note: The core was very fluid after thawing.
Cross contamination among sections may have occurred.

Station 21

Collection - Phleger Gravity Corer

Total penetration - 71.1 cm

Total core length - 22.2 cm

Description

0 - 2.54 cm
2.54 - 5.08 cm
5.08 - 15.2 cm
15.2 - 22.2 cm

Unconsolidated, dark brown silt.
Gradation to gray matter.
Dark gray matter.
Gray clay (the surface of the core
was yellowish-brown; coloring possibly
carried down from the surface layer).

Station 22

Collection - Phleger Gravity Corer

Total penetration - 17.8 cm

Total core length - 17.8 cm

Description

0 - 3.18 cm	Thin layer of dark brown silt overlaying sand and gravel. Some plant detritus.
3.18 - 5.72 cm	Gradation to brown clay; some roots.
5.72 - 17.8 cm	Brown clay; some rocks and gravel. Roots in the bottom 2.54 cm.

Standley Lake

Station SL-4

Collection - Phleger Gravity Core

Total penetration - 10.2 cm

Total core length - 10.2 cm

Description

0 - 5.08 cm	Silt and fine sand.
5.08 - 10.2 cm	Brown clay.

Note: Roots throughout the length of the core.

Station SL-5

Collection - Phleger Gravity Core

Total penetration - 41.9 cm

Total core length - 15.2 cm

Description

0 - 4.45 cm
4.45 - 10.2 cm
10.2 - 15.2 cm

Silt overlaying grayish-brown clay.
Grayish-brown and brown clay.
Predominately sand; very little clay.

Station SL-7

Collection - Phleger Gravity Corer

Total penetration - 30.5 cm

Total core length - 19.1 cm

Description

0 - 2.54 cm
2.54 - 19.1 cm

Dark brown silt.
Sand-clay mixture grading to sand.

Station SL-8

Collection - Phleger Gravity Corer

Total penetration - 15.2 cm

Total core length - 14.0 cm

Description

0 - 2.54 cm
2.54 - 5.08 cm
5.08 - 8.89 cm
8.89 - 14.0 cm

Silt and sand.
Sand and grayish-brown clay.
Grayish-brown clay; some sand.
Light to dark brown clay; some sand.

Station SL-12

Collection - Phleger Gravity Corer

Total penetration - 22.9 cm

Total core length - 22.9 cm

Description

0 - 5.40 cm

Sandy silt; dark brown.

5.40 - 5.72 cm

Gradation to grayish-brown clay.

5.72 - 14.0 cm

Gradation: grayish-brown clay to brown clay.

14.0 - 22.9 cm

Brown clay.

Station SL-13

Collection - Phleger Gravity Corer

Total penetration - 17.8 cm

Total core length - 12.7 cm

Description

0 - 3.18 cm

Dark brown silt and sand; largely
silty sand.

3.18 - 5.08 cm

Gradation to brown clay.

5.08 - 12.7 cm

Brown clay.

Station SL-16

Collection - Phleger Gravity Corer

Total penetration - 116.8 cm

Total core length - 43.2 cm

Description

0 - 25.4 cm

Black "ooze;" "greasy."

The section defined by depth limits
of 2.54 to 5.08cm contained a considerable
amount of plant detritus.

25.4 - 43.2 cm

Clay mixed with the black "ooze."

Coloration of clay ranged from gray to
grayish-brown.

Station SL-17

Collection - Phleger Gravity Corer

Total penetration - 22.9 cm

Total core length - 11.4 cm

Description

0 - 3.81 cm

Dark brown silt and sand.

3.81 - 5.08 cm

Gradation to light brown clay.

5.08 - 11.4 cm

Light brown clay containing sand and gravel.

TABLE B-I

SEDIMENT SAMPLE COMPOSITIONCHERRY CREEK RESERVOIR, MARSTON LAKE, AND RALSTON
RESERVOIR

<u>Station</u>	<u>Composition</u>
Cherry Creek Reservoir	
CC-1	Gray silt
CC-2	Gray and black silt
Marston Lake	
M-1	Silt and sand
M-2	Brown and gray silt
Ralston Reservoir	
R-1	Mixture of sand and gray silt
R-2	Brown and gray silt
R-3	Brown and gray silt
R-4	Brown and gray silt
R-5	Gray silt